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Personal computer use at Navy Field Activities: a productivity study

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PERSONAL COMPUTER USE AT NAVY FIELD
ACTIVITIES: A PRODUCTIVITY STUDY

by

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and

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In the past, corporations justified investment in office automation (OA) by vague claims of increased productivity. Now, managers are reevaluating their productivity measurement systems in an effort to identify productivity gains resulting from OA. The purpose of this thesis is to present a methodology for determining the impact of OA on office productivity. This study examined the productivity of the Standard Automated Contracting System for Federal Agencies (SACONS), in a before/after quasi-experimental design that measured outputs (volume, quality of work), inputs (staff size, grade structure, overtime usage), and by-product social effects (morale, teamwork) using archival data. This framework, developed in a previous SACONS study, is used to analyze the strength of SACONS software. The results of this study were confounded by external

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Personal Computer Use at Navy Field Activities: A Productivity Study

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ABSTRACT

In the past, corporations justified investment in office automation (OA) by vague claims of increased productivity. Now, managers are reevaluating their productivity measurement systems in an effort to identify productivity gains resulting from OA. The purpose of this thesis is to present a methodology for determining the impact of OA on office productivity. This study examined the productivity of the Standard Automated Contracting System for Federal Agencies (SACONS), in a before/after quasi-experimental design that measured outputs (volume, quality of work), inputs (staff size, grade structure, overtime usage), and by-product social effects (morale, teamwork) using archival data. This framework, developed in a previous SACONS study, is used to analyze the strength of SACONS software. The results of this study were confounded by external events that adversely affected our results. Only the quality of work measure (Procurement Action Lead Time), which was reduced by 13 percent, showed a significant productivity gain. Further study of SACONS is necessary to determine its impact on office productivity.

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I. INTRODUCTION

The goal of this study is to present a method for determining whether automation increases productivity in an office setting. To assess the impact of office automation (OA) on office productivity, we studied a newly installed Standard Automated Contracting System for Federal Agencies (SACONS). SACONS has been in operation for one year at a Navy site we call NAS Sloat. This is a follow-on study to one previously conducted at an Army installation called Ft. Saxon.[1] We used the framework provided by the Ft. Saxon study to compare our results and analyze the strength of the SACONS software.

SACONS is an automated procurement system. It is a local area network data base management system that is used to perform various supply functions such as receipt control, large purchase contracting and small purchase contracting. The focus of our study is SACONS' small purchase contracting subsystem, which is used for purchases under $25,000.

SACONS literature boasts of increased productivity resulting from system use. According to Greenwood (1984), productivity is a measure of efficiency and effectiveness.

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[1] Impact of Office Automation: An Empirical Assessment, by Steven C. Barclift and Desiree D. Linson, Naval Postgraduate School, Monterey, California, December 1988.

Efficiency involves comparing inputs to outputs: how much or how little input is required for acceptable output, or conversely, how much output is acceptable given a fixed level of inputs. Effectiveness involves attainment of goals: for example, how a program or system affected profits if maximizing profits were the organizational goal (Urban, 1986). To empirically test the validity of SACONS' productivity claims, we used the industrial engineering definition of productivity: the ratio of outputs divided by inputs. Therefore, if a measure of output increased, a measure of the input required decreased or a combination of the two occurred simultaneously, the productivity ratio became larger.

At NAS Sloat, the inputs studied are the number of people in the small purchase activity, structure of civil service grade and the amount of overtime used. The outputs are purchase request workload and Procurement Action Lead Time (PALT). The PALT is defined as the amount of time that elapses after a purchase action request reaches Issue Control until a purchase order is issued plus one day. PALT is used as a measure of effectiveness, an indicator of improvement in the quality of the procurement process as a result of OA. We used archival and current data to determine PALT before and after the implementation of SACONS. This empirical evidence will be used to assess the impact of SACONS on office productivity. This study, like

the one conducted at Ft. Saxon, also focused on the organizational and behavioral issues of productivity. The following is a summary of what we studied:

- The use of experimental design in data collection and hypothesis testing;
- The effect that SACONS has on the PALT using archival and current data; and
- Empirical evidence of the social impacts of SACONS, using archival and current data.

II. LITERATURE REVIEW

The last decade has been characterized by two trends: a spiralling availability of computer technology and a dramatic shift in the workforce from blue-collar to white-collar. As a result, organizations have spent billions of dollars automating their offices in the hope of reaping the white-collar productivity benefits promised by the computer industry. Managers in these same organizations now "fear that the potential benefits extolled by OA champions will never be realized." (Urban, 1986, p. 4) Recent computer industry literature such as PC World, Computerworld, and Byte give credence to this skepticism by revealing that computerization is no longer automatically synonymous with increased productivity.

The day of reckoning has come, no longer will investment in office automation be justified by the vague claim that it will increase productivity. According to Charles Callahan (EDP, 1985), "managers want to see bottom line payoffs" (p. 4). Not surprisingly, organizations such as General Telephone and Electronics (GTE) and Westinghouse are reevaluating their productivity measurement systems in an effort to assess the benefits of OA.

A. WHAT IS NOT HERE

We could find little in the academic literature that dealt with productivity measurement of knowledge workers (professional, technical, managers and administrators). The difficulty in quantifying the output of these professionals seems to be the primary reason for the lack of information on measuring their productivity. The measurement of the productivity of knowledge workers is not the subject of this study. Rather, the focus here is on the productivity of clerical workers.

B. BASIC INPUT/OUTPUT MEASUREMENT

The definition of productivity embraced by this study is the strict, industrial engineering definition: the ratio of outputs to inputs. Using this definition, productivity measures can be converted to output per worker per hour, output per unit of material or output per unit of any other physical, measurable or countable unit that describes what an organization does to achieve its goal. (Christopher, 1986)

Bain (1982) contends that productivity is not merely a measure of output produced, but a measure of how well resources are combined and used to achieve specific, desirable results. He believes that productivity ratios, such as those described by Christopher, are influenced by various factors within the workplace. These factors include

the quality and the availability of materials, the rate of capacity utilization, the attitude and skill level of the workforce and the motivation and effectiveness of management. Therefore, when measuring productivity, it is important to consider the way in which these factors interrelate and their influence on the specific ratios.

C. IMMEASURABLE PRODUCTIVITY

Measuring the impact of office automation on white-collar productivity is considered fruitless because the output of office workers is varied and largely intangible. According to Rowe (1981), the great nemesis of measuring white-collar productivity has been the inability to quantify the end results of the white-collar employee. Goldfield (1983) states that the difficulty in quantifying white-collar productivity is in assigning a dollar value to creative and intangible activities that may or may not result in tangible benefits to the company. Borko (1983) cites the tendency to measure activities that are easily countable, to ignore activities that are not quantifiable and to deal with quantity and not the quality of outputs as an obstacle to measuring white-collar productivity. He also states that there is difficulty in determining the timeframe in which to measure productivity, because the work done by a worker in one period may not show results until some future period. Cook (1988) sees difficulty in measuring improved

customer services, work quality, timely information needed for decision making and improved employee morale as a result of office automation (OA).

A. Perry Schwartz, president of Computer Research Associates, Inc., a software development and consulting firm, claims that with an absence of headcount reduction, there is no easy way to assess white-collar productivity (Schwartz, 1987). This does not mean that there is no benefit from OA, but that measuring the results requires more than just tracing improvements in white-collar work to a bottom line. He stated that the output of white-collar activity is frequently intangible, uncountable and not easily related to revenue. Therefore, the numbers to make the calculations and build a model to measure productivity are often unavailable.

D. SUBSTITUTING ATTITUDE SURVEYS FOR INPUT/OUTPUT

Parsons, as quoted by Leeke, contends "that if a worker feels like he is more productive using a computer than he probably is." (Leeke, 1987) He believes that quantifying white-collar productivity is unnecessary. Instead, Parsons suggests that substituting traditional input/output measures with attitude surveys is a more appropriate method for gauging office productivity. Attitude surveys attempt to measure opinions through a questionnaire administered to a set of individuals.

The attitude survey is most useful when job satisfaction can be used as a key indicator of productivity. Carlson (1974) cites the following problems with using attitude surveys:

- Trying to quantify what cannot be quantified causing the subsequent analysis to be misleading;
- Questionnaire respondents may interpret questions differently than intended;
- Administering questionnaires is inconvenient and expensive; and
- Questionnaires do not identify the causes of any measured changes.

Although some experts prefer the use of attitude surveys for assessing the benefits of office technology, quantitative methods are likely to remain important because top management wants proof on paper that installing new systems pays off (Six, 1987).

E. VARIETIES OF INPUT/OUTPUT ANALYSIS

Sink defines productivity measurement as "the selection of physical, temporal and perceptual measures for both input variables, output variables and the development of a ratio of output measures to input measures." (Sink, 1985, p. 25)

According to Sink, there are two basic categories of pure productivity measures. The first is a static productivity ratio in which measures of output are divided by measures of input for a given period of time. The second category is a dynamic productivity index which gives a

static productivity ratio at some previous period in time. There are three types of productivity measures within each category:

- The partial factor measure which uses one class of input such as labor or capital;
- The multifactor measure which uses more than one class; and
- The total measure which uses all classes of inputs.

Sink defined productivity as the relationship between the outputs generated from a system and the inputs provided to create those outputs. Dissecting this definition, it can be seen that the numerator reflects quality and quantity, or in other words effectiveness. On the other hand, the denominator reflects efficiency in the way resources are actually consumed.

Sink states that a measurement system should consist of ratios of output measures and input measures and indexes. The measure of output and input could be specific measures of quantities of any resource used and quantities of any good or service produced as output.

Finally, Sink lists the following ways in which productivity can reflect improvement:

- Output increases while input decreases;
- Output increases while input remains constant;
- Output increases while input increases at a slower rate;
- Output remains constant while input decreases; and

- Output decreases while input decreases at a more rapid rate.

F. API: LOCALIZED APPLICATION OF INPUT/OUTPUT

The Administrative Productivity Indicator (API) is a continuous quantitative system that focuses on reducing headcount and improving administrative productivity. Bolte created this system for Intel Corporation in an effort to dispel the myth that white-collar productivity is immeasurable (Bolte, 1983).

In developing the API, Bolte used the classical definition of productivity to define the output of white-collar workers: physical units of work output divided by the number of employee hours required to produce it. According to Bolte (1983), this straightforward approach was used so that lower level management could easily understand the API and use it to make productivity improvements. Bolte also viewed administrative areas as "paper processing factories" with specific inputs and required outputs so that production line techniques could be used to measure productivity and a base-line index calculated (Bolte, 1983, p. 48).

The API can be used where a single output can be defined as the measure of the performance of an organization. The API is simply work output divided by labor hours input and is expressed in hours per unit (HPU). Output must be physical and countable and reflect the organization's goals,

whereas, input is the actual number of labor hours required to produce the output.

The API measures changes in productivity over time. As a result, it can be used by management to gauge the effect of certain policies on productivity. For example, once the API is established, and a base HPU is determined, efforts are made to reduce this beginning HPU. This is accomplished by simplifying work tasks or applying workload management techniques. According to Bolte, this procedure will eventually lead to a reduction in headcount, and thus, indicate increased productivity (Bolte, 1983).

G. MOPI: MULTIPLE OUTPUT PRODUCTIVITY INDICATOR

The Multiple Output Productivity Indicator (MOPI) is a general measure of productivity that is used when organizational goals are defined by several outputs making analysis of a single measure of output inadequate (Christopher, 1986). Some of these outputs may be quantifiable, while others may require subjective appraisal.

To calculate MOPI, management identifies outputs that are measurable and describe organizational goals. They then establish a rating scale technique that will ultimately be used to produce a single overall MOPI. Like the API, this model has been applied in administrative organizations to monitor and improve productivity performance.

H. CONSENSUS MODEL: LOCALIZED ADAPTATION OF INPUT/OUTPUT

Constructing direct output models to measure productivity gains in white-collar work is difficult and often infeasible. Schwartz (1987) discussed several different cost-benefit analysis techniques that rely on inferring outputs rather than directly measuring them for use in these cases. The consensus model, used by General Telephone and Electronics, projects benefits by seeking agreement among managers on the range of payoff expected from the introduction of a specific computer technology. Managers are asked to estimate the value of a task and share their estimates and reasoning. After repeated estimates and sharing, a consensus is formed on the dollar value of the task. The assumption is that an increase in profit is an indicator of increased productivity. The consensus model uses data such as profit per employee, sales figures, market research, costs of operations or other financial data to set upper and lower limits. It is important to recognize that despite these seemingly quantitative bounding measures that the estimates are basically subjective. The consensus model should be used when there is a limited quantitative basis for making estimates of value.

I. COST DISPLACEMENT MODEL

In the Cost Displacement Model, a common type of direct input model, inputs can be exactly determined, but outputs

cannot be measured (Schwartz, 1987). This model assumes that outputs remain at the current level. Schwartz explains that if outputs actually do remain constant, and the number of inputs are cut, then clearly it can be inferred that productivity (output divided by input) has increased. The actual amount of increase, however, cannot be determined.

The greatest advantage to the cost displacement model is its simplicity: it merely requires that real labor cuts be made or actual equipment savings be achieved in response to the introduction of new information technology. The disadvantage is that without a real reduction in headcount or equipment costs, cost displacement models are inappropriate.

J. INFERRED INPUT MODEL

Inferred Input Models (Schwartz, 1987) are the most frequently used type of cost-benefit analysis models for information systems. These models use projected increases in efficiency and effectiveness among workers rather than actual, verified cuts in labor or headcount. These projections are based on the development of a task/time matrix that jointly reflects the amount of time workers devote to activities and the time-savings impact of computer technology.

The time-savings/time-salary (TSTS) model is the most common form of inferred input model. Developed by IBM based

on extensive research by Booz, Allen & Hamilton, Inc., this model asks office professionals to estimate the time they spend in specific activities, such as reading, typing and talking on the telephone. The savings from OA are computed as a percentage increase in efficiency multiplied by labor cost. The appeal of this model is that it is simple and easy to use. It is important to remember, however, that simplicity is also the TSTS model's flaw. The model counts time saved on lower value activities as being equivalent to savings on higher value activities. Therefore, although TSTS can determine whether efficiency has improved, it cannot measure increased effectiveness.

According to Schwartz (1987), TSTS should only be applied to situations where the growth in volume or revenue is reasonably certain, where the time savings is expected to be approximately equal across all activities, and where there is a commitment to keep a cap on headcount.

K. WORK VALUE ANALYSIS

The Work Value Analysis (WVA) is a hybrid model developed by Schwartz (1987) in response to problems in using direct output models and the shortcomings of the inferred input models. This model is designed to identify the value of office information systems based on their power to allow white-collar workers to enhance their performance of primary activities (those directly related to

organizational goals) while reducing their need to perform support or clerical tasks. WVA recognizes that white-collar workers engage in a wide variety of job-related activities. Schwartz found that professionals spend about 35% of their time on primary activities and 45% of their time on support or clerical activities. The remaining 20% of professionals' time is spent on such activities as looking for misplaced or misfiled information, traveling, and waiting for others. Because time spent on these activities does not further the organization's mission, it is called lost time.

Unlike the previously discussed productivity measurements, WVA not only measures improvements in efficiency, but also explicitly accounts for effectiveness. To improve efficiency, technology can shorten the amount of time required to complete a given task, or it can allow more of the task to be completed in the same amount of time. Effectiveness is increased when the technology causes a shift in the professional's work profile so that more time is spent on primary activities and less on the lower value activities involved in support, clerical and lost time.

Using wages as a benchmark, WVA analytically determines the dollar value of changes in work patterns. The model is based on a system of linear equations with constraints and requires the construction of a set of simultaneous equations, one for each job level, to be solved statistically.

The advantage of WVA is that it provides an objective method for measuring benefits when the value of work, other than salary, cannot be determined. The disadvantage of WVA is its complexity. A great deal of effort must be expended on such activities as time logging and determining worker activity profiles and the mathematical computations can be tedious.

L. NPMM: NORMATIVE PRODUCTIVITY MEASUREMENT METHODOLOGY

The Normative Productivity Measurement Methodology (NPMM) was developed in 1975 at Ohio State University as a result of a two year study of productivity measurement of Administrative Computing and Information Services (Morris and Smith, 1976). NPMM uses nominal group technique (NGT) to develop a prioritized list of performance ratios and "surrogate" productivity measures. The term "surrogate" is used because although the list of productivity measures generated by NGT correlates highly, it does not conform to the strict definition of productivity: outputs divided by inputs. Sink describes NGT as "a carefully designed, structured, group process that involves carefully selected participants in some activities as independent individuals, rather than in the usual interactive mode of conventional groups." (Sink, 1985, p. 121)

The prioritized performance ratios and productivity measures (surrogate) developed through NGT are used by a

productivity analyst to draft a workable productivity measurement system based on organizational goals. The results of this draft are then briefed, reviewed and discussed with the NGT participants to obtain feedback prior to implementation of the final productivity measurement system. Once the productivity measurement system has been approved, it is incorporated into the organizations' already-existing performance measurements. The final stage consists of continuous monitoring and feedback based on the initial productivity measures. Because of its participative nature, the NPMM is best used to evaluate the productivity of smaller units, such as the group level.

According to Sink, "the advantages of the NPMM are shared commitment and understanding and hence higher probability of successful implementation and positive behavior change." (Sink, 1985, p. 139)

M. MFPMM: MULTIFACTOR PRODUCTIVITY MEASUREMENT

The Multifactor Productivity Measurement (MFPMM) is a refined version of the total-factor productivity model originally developed by Hiram Davis.[2] The MFPMM approach is a consultative, data base-oriented system that relies on system documentation as its primary source of data. This is

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[2]Hiram Davis developed the multifactor productivity model while he was a professor at the Wharton School of Finance and Commerce of the University of Pennsylvania. Davis' bookm <u>Productivity Accounting</u>, published in 1955 explains the methodology used to develop this model.

a highly developed and self-contained decision support system that is top-down in character. MFPMM is restrictive in its definition of productivity, using only ratios and indexes to measure productivity. As Van Loggerenberg and Cucchiaro (1982) point out, this third generation total-factor productivity model can be used:

- To monitor historical productivity performance and measure how much, in dollars, profits were affected by productivity growth or decline;

- To evaluate organization profit plans to assess and determine the acceptability and reasonableness of productivity changes in relation to those plans; and

- To measure the extent to which the firm's productivity performance is strengthening or weakening its overall position relative to its competitors.

The MFPMM is comprised of a 19-column matrix that contains data, ratios and indexes. Since MFPMM is an aggregated system, it is necessary to use indexed prices and costs. Davis states that productivity "is always a relative measurement, present versus past performance...." (Davis, 1951). Therefore, past and present snapshots of the organizational system's productivity ratio are developed and compared using this operational matrix. The result is an overall evaluation of the organizations productivity, price recovery and profitability performance.

The MFPMM is a complicated model that is a critical but rather minor component of an application. As Sink states,

> ...integrating the model into an existing control system, collecting the data, getting management to accept and feel comfortable with the system, and selling the system based

> on benefit-to-cost projects are all activities that actually play a more critical role in successful implementation of such a system. (Sink, 1985, p. 166)

The MFPMM is best suited to analyzing intermediate size units such as division, plant or firm levels. Once the system is established, the organization has a method of monitoring white-collar productivity. The MFPMM is useful for quantifying what had previously been deemed unquantifiable.

N. PRODUCTIVITY MAP

Productivity Map is a program developed by Pacesetter Software that uses a survey technique to assess the efficiency of white-collar workers in fulfilling organizational objectives (Heirl, 1988). This program defines productivity as the ratio of goods produced to resources consumed and uses measures of productivity such as quantity, quality, timeliness and cost.

Productivity Map collects data in three stages. First, managers are asked to define the department's mission. Second, employees rate the importance of the products, services, and delivery performance of their departments. And finally, the organization's customers are asked to respond to similar questions. After all the data are collected and analyzed, the results are displayed on graphs that emphasize qualitative measures, such as customer service and timeliness, rather than quantitative measures.

O. BOSTI

Buffalo Organization for Social and Technological Innovation (BOSTI) measures the effects of work environment on productivity and quality of work life (Brill, 1988). It shows how certain facets of the office environment affect job satisfaction and performance. BOSTI believes that productivity can be improved and measured as a result of improvements in office surroundings.

P. FT. SAXON STUDY

The Ft. Saxon study examined the productivity of the SACONS system in a before/after quasi-experimental design that measured outputs (workload, quality of service), inputs (size of staff, staff grade structure, usage of overtime) and by-product social effects (morale, teamwork, and professionalism) using archival data. Barclift and Linson (1988) found that while workload increased slightly, the quality of work measure (PALT) improved over 30 percent after automation. This result was obtained as the size of the staff decreased. In addition, overtime usage declined sharply after automation. Rather than being perceived as a threat, this study found that SACONS was enthusiastically received by the office workers and that it removed drudgery from jobs. As a result, nagging backlogs were reduced. The added time available for training contributed to increased professionalism and group cohesion. According to Barclift

and Linson, this all led to improved morale, as indicated inversely by reduced sick leave usage. In determining the impact of SACONS on office productivity, this study was also able to identify a headcount reduction resulting from automation, and to quantify a cost recovery period for the cost of the SACONS.

Q. SOCIAL EFFECTS OF OFFICE AUTOMATION

Organizations have invested in computer technology in an effort to increase office-worker productivity. But instead of being able to boast about an efficient new work place, they are confused by employees' negative reactions to the new technology and their inability to use it effectively.

> Such terms as "computerphobia," "cyberphobia," "technophobia" and "'technostress" characterize the resistance to change in the work place and emphasize how critical it is to understand and plan for the human perspective when installing new technology. (Faerstein, 1986).

Faerstein cites such feelings as the need for control, resistance to change, the need for status and power, the fear of failure and the feeling of isolation, as factors that lead to computer anxiety. He states that automating the work place can only be effective if employees' fear about their job and their status are faced.

R. WHAT WE FOUND

Having surveyed the literature, we found the following:

- An assertion by the computer industry that computerization of office work will always lead to productivity improvement;
- No documented measurement of productivity improvement resulting from computerization of office work;
- Management becoming increasingly skeptical about the benefits of computerization, and thus less willing to invest in OA;
- A movement to replace the efficiency definition of productivity (output/input) with a survey assessment of job satisfaction;
- A perception of productivity measurement as an adjunct of productivity improvement programs.

S. OUR GOAL

Our aim was to:

- Establish an empirical basis for measuring productivity gains resulting from office automation;
- Base this methodology on a before/after experimental design;
- Use the industrial engineering definition of productivity (the ratio of output divided by input) as the basis for this study;
- Conduct an office automation productivity study independent of the biasing politics of productivity improvement programs; and
- Compare the findings at NAS Sloat with those at Ft. Saxon based on the framework provided by the Ft. Saxon study.

III. METHODOLOGY

A. CONDUCT OF THE STUDY

1. Prelude to the Sample

The primary investigators sampled data from a military purchasing field organization: the Purchasing Branch of the Supply Department located at NAS Sloat. The selection of this site was based on our desire to conduct a follow-on productivity study of the Standard Automated Contracting System (SACONS), a small-purchase software program designed for the Army.[1] In the original SACONS study conducted at Ft. Saxon, SACONS led to a significant improvement in productivity.[2] This study of the first Navy installation of SACONS allowed us to measure productivity at NAS Sloat and compare that data to the Ft. Saxon study.

Similar to the Ft. Saxon study, we collected data in a before/after design. Before the installation of SACONS, small-purchase contracting was done manually. A description of the manual requisitioning system is provided in Appendix

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[1]Hardware for SACONS consisted of a standard desk-top system configured as a Local Area Network. Additional hardware information can be found in Appendix A.

[2]Productivity was measured by the change in Procurement Action Lead Time (PALT) and the number of labor hours per purchase. Post-SACONS PALT was reduced by 33.47 percent and labor hours per purchase was reduced by 16 percent during the year after SACONS was installed at Ft.Saxon.

B. The pre-SACONS data was gathered using archival records. The post-SACONS data was generated by the SACONS system.

As a result of a Procurement Management Review conducted in April 1989, NAS Sloat's procurement authority was suspended during May, June and July, 1989. A contracting officer from the inspection activity was physically stationed at NAS Sloat to approve all purchases during these months. The loss of procurement authority caused an abnormal delay in the requisitioning process and had an adverse effect on the Procurement Action Lead Time (PALT). PALT, an indicator of quality of output, is the time required to process and award a contract for a requisition. Since this period did not accurately reflect SACONS productivity, a second analysis was conducted excluding this period.

During the months of reduced procurement authority, additional time was used to train personnel on purchase procedures and SACONS. Consequently, the overall SACONS learning curve of the Purchasing Branch may have been affected during the months that followed. The additional training offset the reduction in the volume of requisitions and the actual use of SACONS caused by the loss of procurement authority.

Meetings were held between the principal investigators and the supervisory personnel in the Purchasing Branch at NAS Sloat preceding the collection of archival

data. The purpose of these meetings was to establish a working relationship with the supervisory personnel and to assure them that our data collection would have minimal impact on their operation.

We had hoped to measure the before/after effect SACONS had on worker satisfaction. Additionally, we wanted to conduct an attitudinal survey before the installation of SACONS and after the installation of SACONS. However, the supervisory personnel had reservations about the time required to complete the surveys. Moreover, they did not approve of certain survey questions that were perceived to be confronting. In compliance with their wishes, we did not administer this survey before the installation of SACONS. This part of the study was sacrificed to maintain a working relationship with the Purchasing Branch and to facilitate the collection of archival data on productivity.

2. <u>SACONS Described</u>

SACONS is a small-purchase computer-based software system, designed to support the purchase and contracting efforts of Department of Defense field activities. The system permits real-time access to contracting information by all levels of management, as well as limited access by authorized customers. The limited access provides the customer with the status of a requisition. SACONS currently supports the performance of daily contracting procedures and is designed to meet projected future contracting

requirements. SACONS is described further in Appendix D.

3. <u>Experimental Design Development</u>

To develop a means to evaluate productivity, we decided that three types of data would be collected.

a. Inputs

Quantitative factors in the work place, such as the size of the staff, grade structure and overtime worked will be measured.

b. Outputs

The Procurement Action Lead Time (PALT) is the measure of time it takes to process a requisition, that is, the amount of time that elapses after a purchase action request reaches Issue Control until a purchase order has been issued. PALT indicated the quality of work done. The number of requisitions processed per time period indicated the volume of work. The number of labor hours required to produce a single purchase is the indicator of productivity.

c. Social Effects

The effects of automation on worker satisfaction will be measured by the changes in annual leave and sick leave taken.

4. <u>Analysis</u>

The statistical analysis chosen to evaluate the data is a simple difference of means "t" test.

5. Collection of Data

Archival data from randomly-selected pre-SACONS records was manually reviewed to establish a baseline for the PALT at NAS Sloat. After the installation of SACONS, we used the cumulative monthly report that SACONS generated. This report provided the PALT and the volume of requisitions for each month.

B. THE SAMPLE

The collection of archival data began in the Purchasing Branch of the Control Division in the Supply Department at NAS Sloat. The Control Division consists of two branches, the Purchasing Branch and the Receipt Control/Issue Control Branch. Currently, the Control Division has a total of 16 civilians and nine military. The Purchasing Branch consists of ten civilians. An organization chart of the Purchasing Branch, both before and after SACONS, is provided in Appendix C.

C. DATA COLLECTION DESIGN

We sampled archival data from the records maintained by the Purchasing Branch of the Control Division. The following description indicates how the records were sampled in order to estimate the PALT, before and after the SACONS installation.

1. Before SACONS Installation

There were 12,492 requisitions received from 1 October 1987 to 30 September 1988. As a result of the grouping of requisitions, our population consisted of 4520 individual records. The grouping of requisitions in individual folders occurred when multiple requisitions for similar materials were submitted by one customer. This allowed the awarding of the multiple requisitions as a group to a single vendor.

We randomly selected a sample of six percent from the 4520 records. Using a random number table, we chose the 15th record as our first item. Subsequently, each 15th requisition was selected to provide a total of 301 requisitions for evaluation.

2. After SACONS Installation

The Purchasing Branch stopped manually processing requisitions on 16 October 1988. The Purchasing Branch did not process any requisitions during the week of 17 to 24 October. This week was devoted to SACONS training provided by the contractor. SACONS was installed at NAS Sloat on 24 October. Selection of the post-SACONS data was conducted in a different manner. SACONS generates a monthly listing of all requisitions processed and the average monthly PALT. We randomly selected a six percent sample of requisitions from the listings of SACONS-processed requisitions for the period of 24 October 1988 to 30 September 1989. As noted above,

the PALT for May, June, and July was not recorded because of the loss of NAS Sloat's procurement authority during these months.

3. Additional Measures

We also gathered archival data on the use of annual leave, sick leave, and overtime worked. We used organization charts and manning tables to determine the number of personnel employed by the Purchasing Branch of the Control Division and their grade structure.

Figure 1 represents the interaction of inputs and outputs, both before and after the installation of SACONS at NAS Sloat. The null hypotheses states that data sampled from the pre-SACONS installation period are statistically the same as the post-SACONS period. If the data are statistically indistinguishable, then the null hypothesis cannot be rejected. On the other hand, if the data are statistically distinguishable, the null hypothesis must be rejected and the alternative hypothesis is accepted. The alternative hypothesis concludes that the pre-SACONS mean PALT is greater than the post-SACONS mean PALT.

D. INSTRUMENTATION

1. Inputs

Several inputs into the requisitioning process of the Purchasing Branch were measured. They included:

	Observation 1 Before Automation	Observation 2 After Automation
Inputs	Staff Size	Staff Size
	Dollars of Labor	Dollars of Labor
	GS Structure	GS Structure
Outputs	PALT	PALT
	No. of purchase requests	No. of purchase requests
	No. of labor hours per purchase	No. of labor hours per purchase

Figure 1. Productivity Matrix

- the before/after mean annual numbers of employees;
- the before/after mean annual GS levels of the staff;
- and the before/after mean bi-weekly hours of overtime worked.

The mean annual number of employees is a measure that shows the average number of people available to staff the Purchasing Branch. The mean annual GS level of the staff represents the level of expertise of these employees. It also represents the level of payroll expenditure. The bi-weekly overtime worked represents the extra time authorized at the job to complete the work. Overtime is usually the result of an increased workload or a temporary reduction of available employees.

2. Outputs

Outputs of the requisitioning process were measured in three different ways:

a. Quality

The before/after measure of PALT or quality of work performed. The quality of work is a measure of the average time taken to process and award requisitions.

b. Quantity

The before/after number of requisitions processed or volume of work performed. The volume of work is represented by the mean monthly number of purchase requests processed. This is the average number of requisitions processed each month.

c. Efficiency

The before/after number of labor hours consumed per purchase completed.

We have chosen PALT as a measure of effectiveness.[3] The PALT is a measure of quality. It represents the time required to process and award a contract for a requisition. Requisitions are prepared by military units within NAS Sloat and various tenant activities and submitted to the Control Division for purchase. Upon receipt in the Issue Control Branch, requisitions are stamped with the

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[3]We define a measure of effectiveness as the quality measure of work in the office environment from the perspective of the customers of the purchasing activity.

date, beginning the PALT period. The date when the requisition purchase orders are awarded to a vendor ends the PALT period. When a requisition is awarded on the same day it is received, the procurement period is one day. The difference between the award date and the date of receipt of the requisition, plus one day, defines the PALT.

A change in productivity can be measured by analyzing the ratio of inputs to outputs. Various inputs into a system or process are required to produce a given output. If the system or process is changed so as to require fewer input resources, or to produce a greater quantity of output, productivity is enhanced.

3. <u>Social Effects</u>

The original SACONS study addressed the impact of SACONS on morale and small-group dynamics. During our exploratory discussions with supervisory personnel, these issues were also addressed. The positive social effects included reduced workload and stress, as well as increased teamwork, training, and professionalism. We used the following items to measures these social effects:

- the annual leave taken; and
- the sick leave used.

Annual leave and sick leave are not direct measures of input or output in the requisitioning process. However, they represent worker satisfaction or stress resulting from the work environment where the requisitioning process

occurs. Since management has less control over sick leave than annual leave, sick leave usage is a stronger indicator of worker satisfaction.

E. ANALYSIS STRATEGY

1. Procurement Action Lead Time (PALT)

A difference of means test was applied to the PALT on a month-by-month basis, comparing the manual system used before the installation of SACONS with the automated system of SACONS. Our null hypothesis stated there is no change in PALT as the result of the introduction of SACONS.

A sample of six percent of the records was analyzed during the 12 month period before the installation of SACONS. This analysis yielded a total of 301 pre-SACONS records. A six percent sample of the SACONS generated PALT, with the exception of May, June, and July, 1989 was used for the post-SACONS analysis. We did not test our hypothesis on the quantity of requisitions received because it was independent of the installation of SACONS.

A difference of means test was also applied to test efficiency and social effect. Our null hypothesis for efficiency stated there is no change in the before/after mean numbers of labor hours consumed per purchase completed. Our null hypothesis for social effect stated there is no change in the before/after mean numbers of sick leave and annual leave days taken.

2. Choosing the Appropriate Statistical Test

Student's t-test is appropriate to test hypotheses of two populations where the samples may be either dependent or independent of each other. (Berenson and Levine, 1986) The t-test was applied to test the difference of means of various measures, before and after the installation of SACONS.

The samples drawn from each population were treated as independent for the following reasons:

- The employees of the Purchasing Branch were not identical during the before and after periods;

- Employees were not matched one-for-one between the before and after periods. Information on employees regarding age, sex, educational level, and experience level was not collected.

The null hypothesis states that the two population PALT means are statistically the same. (Ho: X1 = X2) The alternative hypothesis states that the pre-SACONS measure of PALT is greater than the post-SACONS measure of PALT to a statistically significant degree. (H1: X1 > X2)

The following data are summarized in Table 1 from the samples drawn from the two populations, before and after the installation of SACONS.

The degrees of freedom for our t-test approaches infinity on a standard t-table. A one-tailed t-test is selected because we are predicting direction. Reading across the standard t-table we find the following significance levels reproduced in Table 2.

TABLE 1

NUMBER OF ITEMS SAMPLED, STANDARD DEVIATION, AND MEAN

Before SACONS	After SACONS
N1 = 301	N2 = 342
S1 = 16.7	S2 = 17.6
X1 = 17.4	X2 = 15.1

where: N = Sample size
S = Sample standard deviation
X = Sample mean

TABLE 2

T-TABLE SIGNIFICANCE LEVELS

Significance Level	t-score
.01	2.326
.05	1.650

We chose the .05 level of significance to test all measures.

IV. FINDINGS

A. INPUTS

Measures of inputs to the Purchasing Branch at NAS Sloat were collected and summarized in the following categories:.

- Size of the Staff;
- Grade Structure; and
- Overtime worked.

These measures were collected before and after the installation of SACONS.

1. Mean Staff Size

a. Before Automation

The mean size of the staff before automation was 9.8. This represents the period from 25 October 25 1987 to 22 October 1988. Data were collected from the comptroller's report for each two-week pay period. The standard deviation was 0.9.

b. After Automation

The average size of the staff after the installation of SACONS (24 October 1988) was 12.3 persons. Data were collected from 23 October 1988 to 21 October 1989. The standard deviation was 0.8.

c. Testing the Null Hypothesis

The null hypothesis for staff size stated that the staff size of the Purchasing Branch, before and after

automation, was statistically the same. This hypothesis was rejected at the .05 confidence level. Therefore, the alternative hypothesis, that the staff size before automation was statistically different from that after automation, was accepted. Staff size was found to be significantly larger after automation.

2. Mean Grade Structure

a. Before Automation

The mean grade structure of the Purchasing Branch was 6.3 GS level. This mean was calculated from the data in Appendix E. The standard deviation of the grade structure was 0.1.

b. After Automation

The average grade structure of the staff after automation was 6.1 GS level. This mean was calculated from the data in Appendix E. The standard deviation was 0.1.

c. Testing the Null Hypothesis

The null hypothesis for the mean grade structure stated that there was no difference between the populations in the before and after installation periods. This hypothesis was rejected at the .05 confidence level. Therefore, the alternative hypothesis, that the grade structure before automation was statistically different from that after automation, was accepted. Grade structure was found to be significantly smaller after automation.

3. Mean Overtime

a. Before Automation

Overtime worked by the Purchasing Branch personnel was calculated as the mean of the number of hours worked for the entire staff for each two-week period. The average overtime used was 31.4 hours per pay period and 3.2 hours per person. The standard deviation of overtime hours worked for the Purchasing Branch was 73.6 and 7.5 per person.

b. After Automation

The mean overtime hours worked by the entire staff per each two-week period was 34.6 and 2.8 per person. The standard deviation for the Purchasing Branch was 88.2 and 7.2 per person.

c. Testing the Null Hypothesis

The null hypothesis stated that there was no difference in the before and after periods for the cumulative mean overtime used by the Purchasing Branch. This hypothesis could not be rejected at the .05 confidence level. The difference in mean overtime hours used was statistically insignificant.

The null hypothesis for the mean overtime worked per person per two week period could not be rejected at the .05 confidence level.

B. OUTPUTS

Measures of output were collected and evaluated in three different ways:

- Quantity of work, which represents the volume of purchase requests processed per period;
- Quality of work, which is represented by the Procurement Administration Lead Time (PALT); and
- Efficiency of work, which is represented by the number of labor hours consumed per purchase completed.

These measures of output were externally affected by the Procurement Management Review (PMR) conducted in April 1989. The PMR suspended procurement authority at NAS Sloat during the months of May, June, and July, 1989. This suspension reduced the volume of requisitions processed. Since labor hours remained constant, the reduced volume decreased the efficiency of the Purchase Branch. Also, the PALT increased during the affected months. In order to present a more accurate comparison of the before and after results of volume and PALT, two analysis were made. The first analysis included all months during SACONS installation, while the second analysis excluded the suspension months of May, June, and July.

1. Mean Number of Purchase Requests

a. Before Automation

The mean number of purchase requests processed by the Purchasing Branch at NAS Sloat, before the

installation of SACONS, was 1041 requisitions per month. The standard deviation was 248.2.

b. After Automation (Includes All Months)

The average number of requisitions processed per month after the installation of SACONS was 784.7. The standard deviation was 234.8.

c. After Automation (Excludes Data from May, June, and July)

The average number of requisitions processed per month after the installation of SACONS was 885.9. The standard deviation was 190.9.

d. Testing the Null Hypothesis

The statistical significance of the pre- and post-SACONS' mean monthly volume of requisitions was not tested. In the short run, SACONS will not affect the number of requisitions submitted to the Purchasing Branch. The number of requisitions submitted was assumed to be independent of SACONS.

Figure 2, generated from the data in Appendix F, illustrates the number of purchase requests processed from 1 October 1987 to 30 September 1989. SACONS was installed on 24 October 1988. The volume in October includes only the purchase requests processed using SACONS. The variability in requisition submission is caused by the funding patterns and the seasonal nature of requests by the various customer departments.

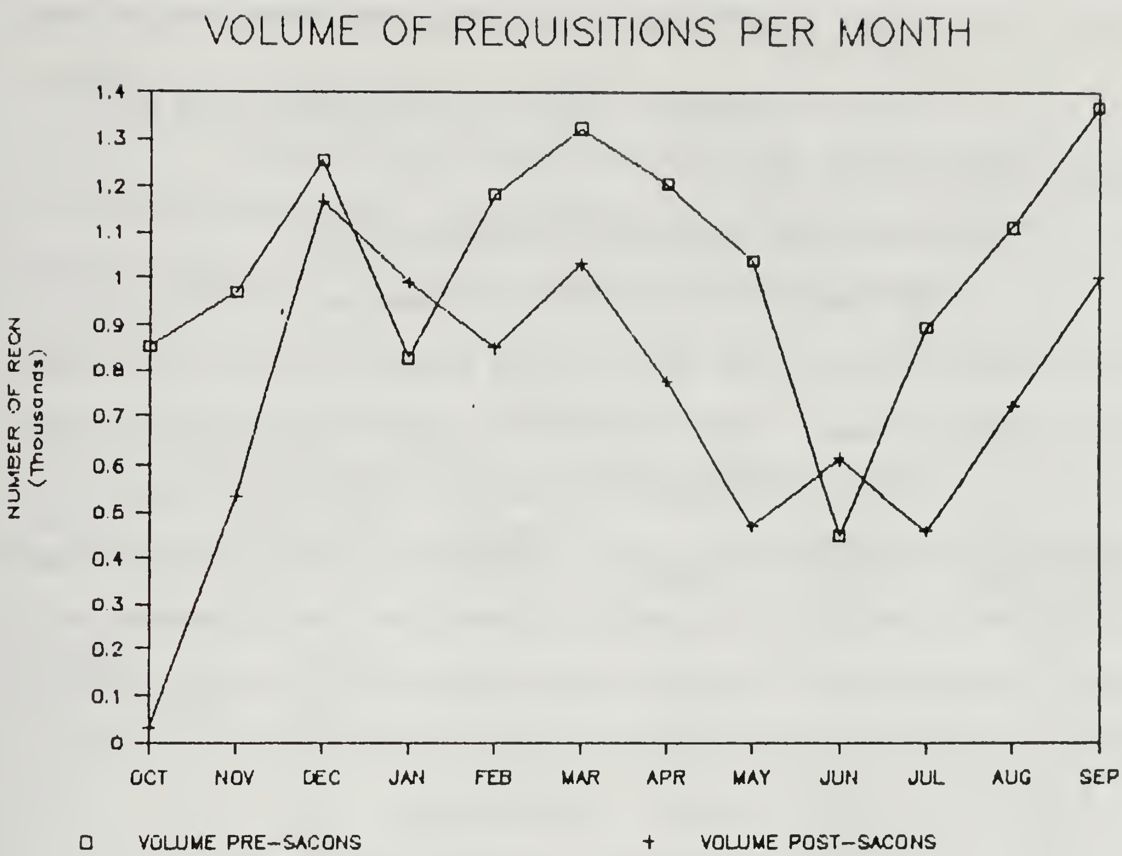

Figure 2. Volume of Requisitions Per Month

2. <u>Mean Procurement Action Lead Time (PALT)</u>

a. Before Automation

The mean PALT before the installation of SACONS was 17.4 days. The standard deviation was 16.7.

b. After Automation (Includes All Months)

The post SACONS' PALT was 15 days. The standard deviation was 17.6.

c. After Automation (Excludes Data from May, June, and July)

The post SACONS' PALT was 14.5 days and the standard deviation was 17.3.

d. Difficult/High Value Requisitions

The supervisor of the Purchasing Branch stated that SACONS reduced the PALT of the more difficult or higher value requisitions. The supervisor stated that requisitions over $500.00 were considered difficult. Before automation, the PALT for requisitions over $500.00 was 21.3 days. After automation, the PALT for requisitions over $500.00 was 16.0 days. The PALT for requisitions under $500.00 was 14.7 days before automation and 14.5 days after automation.

e. Testing the Null Hypothesis

The null hypothesis stated that there was no significant difference in the before and after SACONS mean PALT. This hypothesis was rejected at the .05 confidence level. Therefore, the alternative hypothesis, that the mean PALT was larger before automation was accepted.

Excluding the months of May, June, and July, the alternative hypothesis that the mean PALT was larger before automation was accepted at the .05 confidence level.

The null hypothesis stated that there was no significant difference in the before and after SACONS mean PALT for requisitions over $500.00. This hypothesis was rejected at the .05 confidence level. Therefore, the

alternative hypothesis, that the mean PALT was larger before automation was accepted.

Table 3 provides a summary of monthly PALT data for the entire study. These data were used to construct the monthly comparison of PALT illustrated in Figure 3.

TABLE 3

PROCUREMENT ACTION LEAD TIME BY MONTH

MONTHLY STATISTICS	MAXIMUM PALT	MINIMUM PALT	RANGE	SAMPLE MEAN	STANDARD DEVIATION
OCTOBER 1987	93	1	92	22.7	23.2
NOVEMBER	38	2	36	17.3	8.8
DECEMBER	20	1	19	11.2	5.3
JANUARY 1988	28	2	26	8.7	7.5
FEBRUARY	40	2	38	11.9	11.3
MARCH	67	3	64	15.5	11.5
APRIL	98	1	97	15.9	17.7
MAY	89	4	85	26.1	25.1
JUNE	80	1	79	24.9	21.0
JULY	85	1	84	23.0	24.9
AUGUST	57	2	55	19.5	11.1
SEPTEMBER	65	2	63	14.5	13.9
AVERAGE	63.3	1.2	61.5	17.6	15.1
OCTOBER 1988	49	1	48	25.4	15.5
NOVEMBER	92	1	91	22.6	20.3
DECEMBER	104	1	103	14.1	18.0
JANUARY 1989	108	1	107	11.1	19.2
FEBRUARY	100	1	99	13.7	19.9
MARCH	64	1	63	13.3	13,7
APRIL	58	1	57	12.5	12.8
MAY	77	1	76	15.7	17.4
JUNE	94	2	92	18.7	21.3
JULY	64	1	63	17.9	16.8
AUGUST	51	1	50	15.9	14.9
SEPTEMBER	22	1	21	6.5	7.4
AVERAGE	73.6	1.1	72.5	15.6	16.4

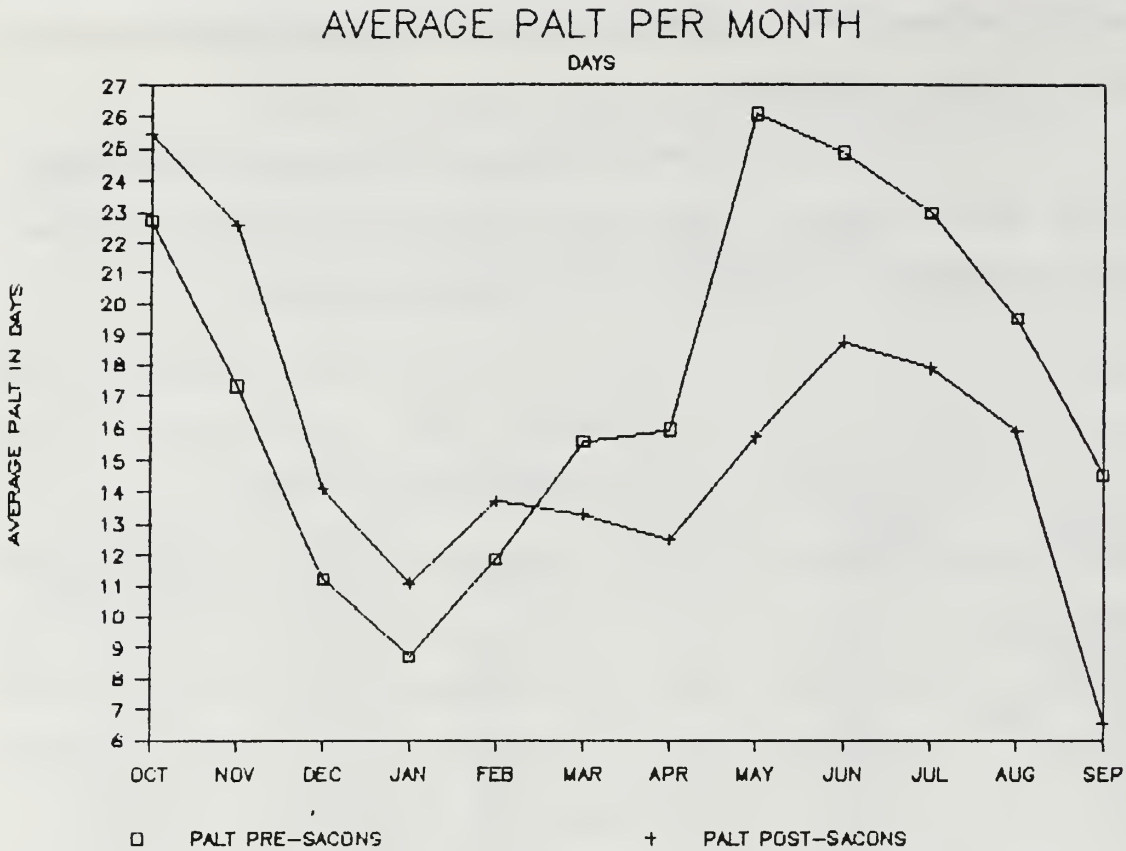

Figure 3. Average PALT Per Month

3. <u>Mean Number of Labor Hours Per Purchase</u>

a. Before Automation

The mean number of labor hours per purchase before the installation of SACONS was 1.6 hours.

b. After Automation (Includes All Months)

The mean number of labor hours per purchase after the installation of SACONS was 2.7 hours.

c. After Automation (Excludes Data from May, June, and July)

The mean number of labor hours per purchase was 2.4 hours.

d. Testing the Null Hypothesis

The mean number of labor hours per purchase was calculated using the average monthly labor hours divided by the average monthly requisitions. The mean number of labor hours per purchase increased from 1.6 hours before SACONS to 2.7 hours after SACONS (Total) and 2.4 hours after SACONS (Partial). Since labor hours were computed on a bi-weekly basis and volume of requisitions was computed on a monthly basis, labor hours were converted into a monthly average for comparison purposes. The statistical significance of this measure cannot be determined using Student's t-test because only one data point was observed in each of the before and after periods.

C. SOCIAL EFFECTS

The amount of sick leave used was collected and evaluated as a social effect resulting from the installation of the SACONS system.

1. <u>Mean Sick Leave</u>

a. Before Automation

The cumulative amount of sick leave taken by the employees of the Purchasing Division, before the installation of SACONS, was 28.8 hours per pay period. The standard deviation was 25.4. In addition, the mean annual sick leave

per person was 2.9 hours per pay period. The standard deviation was 2.6.

b. After Automation

The cumulative amount of sick leave taken by the employees of the Purchasing Division, after the installation of SACONS was 26.9 hours per pay period. The standard deviation was 19.8. Also, the mean annual sick leave per person was 2.2 hours per pay period. The standard deviation was 1.6.

c. Testing the Null Hypothesis for Social Effects

The null hypothesis stated that the mean sick leave usage per pay period (both cumulative and per person) was not significantly different between the before SACONS period and the after SACONS period. The null hypothesis could not be rejected at the .05 confidence level. Therefore, the alternative hypothesis, that the usage of sick leave was statistically the same before and after automation, was rejected.

D. SUMMARY OF FINDINGS

Table 4 summarizes the inputs, outputs and social effects evaluated above.

TABLE 4

SUMMARY OF T-TEST RESULTS

	BEFORE SACONS	AFTER SACONS	T-TEST RESULTS
INPUTS			
Mean Staff Size	9.8	12.3	-10.847
Std Dev	0.9	0.8	
Mean GS Structure	6.3	4.1	6.111
Std Dev	0.1	0.1	
Mean Overtime per period	31.6	34.6	-0.142
Std Dev			
Mean Overtime per worker	3.2	2.8	0.197
Std Dev	7.5	7.2	
OUTPUTS			
Mean Purchase Reqn per month	1041.0	784.7	2.538
Std Dev	248.2	234.8	
PALT (FULL)	17.4	15.1	1.692
Std Dev	16.6	17.6	
PALT (PARTIAL)	21.3	16.0	2.130
Std Dev	20.0	18.4	
Labor Hours per Purchase	1.6	2.7	
SOCIAL EFFECTS			
Mean Sick Leave per period	28.8	26.9	0.299
Std Dev	25.4	19.8	
Mean Sick Leave per worker	2.9	2.2	1.269
Std Dev	2.6	1.6	

V. ANALYSIS AND CONCLUSIONS

A. INPUTS

1. Staff Size

Before automation at NAS SLoat, the number of people required to staff the Purchasing Branch averaged 9.8. After the installation of SACONS, the average number of people staffing the Purchasing Branch increased to 12.3. The Purchasing Branch needed 25.5 percent additional people to perform its mission. Since we are using the industrial engineering definition of productivity (outputs divided by inputs) in this study, it appears that increasing staff size (a measure of input) effectively decreases productivity.

Information gathered during interviews with the Purchasing Branch supervisory personnel indicated that there were several factors independent of the implementation of SACONS that resulted in this increase in staff size. First, personnel turnover in the Purchasing Branch was historically high. Many military spouses were hired and then transferred with their sponsors in a relatively short period. The Purchasing Branch positions were lower graded than similar positions within NAS Sloat. As a result, people transferred out of purchasing to higher graded positions elsewhere within the command. A hiring freeze during FY 88 caused some positions to remain vacant in the face of this

institutional turnover. This, in turn, caused the staff size in the pre-SACONS period to be lower than the authorized manning level. Secondly, a Procurement Management Review (PMR) inspection that occurred in the post-SACONS period determined that the Purchasing Branch was understaffed. This resulted in an increase of six people in the Purchasing Branch's authorized manning level. Two of these people were brought on board during the post-SACONS period of our study increasing the staff size above the authorized pre-SACONS level. Therefore, the increase in staff size was not due to the installation of SACONS. It does, however, represent a counter-productivity outcome.

2. Grade Structure

The average GS grade in the Purchasing Branch before automation was 6.3. After automation it was 6.1. This represents a 3.2 percent decrease in the average grade structure. A decrease in average grade structure is a decrease in an input cost. Therefore, in describing the productivity ratio as outputs divided by inputs, decreasing input costs, all other things being equal, effectively increases productivity.

3. Overtime

The amount of overtime used by the Purchasing Branch before automation averaged 31.4 hours per two-week pay period. The amount of overtime used after the installation of SACONS was 34.6 hours per pay period. Based on these

figures it appears that the use of overtime increased by 10.2 percent. However, our hypothesis test shows that the difference between these two populations is statistically insignificant. Therefore, we have no finding with regard to overtime per pay period.

The amount of overtime used per worker in the Purchasing Branch before automation averaged 3.2 hours per two-week pay period. After the installation of SACONS, the average overtime used was 2.8 hours per worker. Therefore, it appears that overtime per worker decreased by 12.5 percent, effectively increasing productivity. However, our t-test results indicate that the difference between these two populations is statistically insignificant.

Although we found the before and after SACONS populations to be statistically the same with regard to overtime, it is important to note the impact of the three-month loss of procurement authority on this finding. Interviews with the Purchasing Branch supervisory personnel indicated that work backlog increased as a result of the loss of procurement authority. This was because of extra procedural steps imposed during the inspection. This, in turn, caused an increase in the amount of overtime needed later to process requisitions before the end of FY 89. Figure 2 supports this assertion by showing the marked increase in post-SACONS volume during August and September 1989.

Without the three-month loss of procurement authority, the Purchasing Branch may have realized a statistically significant reduction in both total overtime used and overtime used per worker.

B. OUTPUTS

1. Purchase Request Volume

Before the installation of SACONS, the number of purchase requests averaged 1041.00 per month. The number of purchase request averaged 784.7 per month after automation. This represents a 24.6 percent per month decline in the average number of purchase requests. It is important to note, however, that purchase request volume is independent of the presence of SACONS.[1] While the number of requisitions before/after SACONS was not statistically tested, it must be pointed out that a decrease in the number of requisitions processed (a measure of output) constitutes a decrease in productivity.

The volume of purchase requisitions was affected by two factors:

- The Purchasing Branch's loss of procurement authority; and

[1]Purchase request volume was not subject to hypothesis testing because, in the short run, SACONS productivity does not affect demand. Because our findings were confounded by the three-month loss of procurement authority, we were unable to draw any conclusions as to the long run affects of SACONS on the volume of requisitions.

- The increase in the average dollar value of the requisitions processed.

Without procurement authority, all requisitions had to be approved by higher authority. This significantly slowed the procurement process and reduced the number of requisitions completed each month. In addition, we found that although the number of requisitions processed per month declined, the average dollar value of requisitions increased. Costlier purchase requests tend to be more difficult and time consuming than cheaper buys. Therefore, fewer purchase requests were completed because, on the average, each one took longer to process.

2. <u>Procurement Action Lead Time</u>

The Procurement Action Lead Time (PALT) was externally affected by the PMR conducted in April 1989. The PMR suspended procurement authority at NAS Sloat during the months of May, June, and July, 1989. This suspension reduced the volume of requisitions and increased the PALT during the affected months. In order to present a more accurate comparison of the before and after results of SACONS, two analyses were made. The first analysis included all months after the installation of SACONS, while the second analysis excluded the months of May, June, and July.

The time required to process a requisition, a measure of quality of the Purchasing Branch customer service, averaged 17.4 days before automation. After the

installation of SACONS, the time required using the full time was 15.1 days. The partial post-SACONS PALT was 14.5 days. PALT (full) fell by 13.2 percent after automation, while PALT (partial) was reduced by 16.7 percent. The PALT was reduced in both cases indicating an increase in the quality of the Purchasing Branch's service to its users as a result of automation. However, it is evident that the loss of procurement authority negatively affected the time required to process a requisition during the months of May, June and July. Nevertheless, in both cases, raising the quality of outputs constituted an increase in productivity occurring after the installation of SACONS.

We also looked at the effect of automation on difficult requisitions. Before automation, difficult requisitions were set aside for weeks at a time, until a worker felt he or she could give them proper attention. Purchasing Branch supervisors stated that after automation this was no longer the case and that the PALT on these purchase requests had significantly improved. In an effort to substantiate this claim, we calculated the PALT for the more difficult requisitions. Purchasing Branch supervisors agreed that purchase requests greater than $500.00 could be classified as more difficult. Before automation, the difficult PALT was 21.3 days. After the installation of SACONS, the difficult PALT was 16 days. This represents a 24.9 percent decrease in the number of days required to

process difficult requisitions. Therefore, automation had a greater effect on the quality of service for the more difficult requisitions than on the average purchase request.

C. SURROGATE INDICATORS OF SOCIAL EFFECTS

In addition to documenting the productivity resulting from the automation of the Purchasing Branch, we also sought to establish some quantitative evidence of its social and psychological by-products. We were able to gather comparative before/after data on two measures that are surrogate indicators of the social/psychological impact of automation:

- Usage of sick leave;
- Group cohesiveness and professionalism.

1. Sick Leave

Sick leave has been a traditional safety valve for relief from stress and job demands. The sick leave policy provides an avenue for a dissatisfied or stressed employee to escape the demands of his work environment. First, sick leave is earned by an employee and the decision to use it is made solely by him or her, independent of management control. Second, since no documentation is needed from a physician to verify an employee's sickness, sick leave is a ready resort whenever workload and stress are high. Therefore, if the use of sick leave is significantly decreased after the installation of SACONS, other things

being equal, it can be assumed that the environment created by the use of the system is less stressful and is responsible for the decrease in the use of sick leave.

Before the installation of SACONS, Purchasing Branch employees averaged 28.8 days of sick leave per two-week pay period. After automation, 26.9 days of sick leave were used per pay period. Before automation, sick leave used per worker was 2.9 days per pay period. After SACONS, each worker used 2.2 days per pay period. Although this represents a 6.6 percent reduction in cumulative sick leave usage and a 24.1 percent reduction in sick leave per person, our hypothesis tests indicate that the difference between the before/after SACONS populations (cumulative and per person) is statistically insignificant.

It should be noted that sick leave can be accumulated by federal employees and applied for retirement credit. This provides an incentive to the employee to save sick leave. However, because the motivation to save sick leave is the same with or without automation, it does not follow that this had an adverse affect on our finding. It is possible, however, that the added stress involved with the PMR inspection nullified any reduction in stress that may have been brought about by automation.

2. <u>Group Cohesiveness and Professionalism</u>

In order to measure changes in group cohesiveness and professionalism as a result of the implementation of

SACONS we planned to administer an Organizational Universe Survey to the Purchasing Branch staff before/after the installation of SACONS. However, at the request of Purchasing Branch supervisors, we did not use this survey. Therefore, we relied on interviews with supervisory personnel to garner this information. Purchasing Branch supervisors revealed their belief that group cohesiveness and professionalism increased as a result of SACONS. The following are some of the improvements that the supervisors noted:

- Before SACONS, monitoring employee performance was difficult because of the inability to accurately account for the number, status, or complexity of the purchase request. After SACONS, supervisors were able to track the status of each employees' workload, monitor their progress, identify and correct problems, and redistribute workload.

- After SACONS, the Purchasing Branch implemented a team leader concept of management. The two team leaders help the supervisor distribute work, and monitor the workloads of each employee.

- Before SACONS, the more difficult purchase requests were given to the more experienced buyers. The few experienced buyers were almost exclusively processing complicated and frustrating buys. As a result, they had higher than average PALTs. In addition, the newer employees did not learn how to do the more difficult purchase requests. After SACONS, there was more time for training and difficult requisitions are distributed more equally among the buyers, increasing aggregate job satisfaction.

- Using SACONS, employees are able to keep up with their workload. Therefore, they now have more time to help each other and for group training by the supervisors.

- Before SACONS, there was an adversarial relationship between typists and buyers. Each accused the other of being slow, inaccurate, and of losing purchase

requests. After SACONS, buyers entered the data for their own assigned purchase requests, thus alleviating this problem.

- After SACONS, buyers are responsible for their purchase request from start to finish. This resulted in the buyers taking increased pride in their work.

These factors aided in the increase in unit cohesiveness and professionalism. Workers now have more control over the final product, because they are solely responsible for the end product. Therefore, less time and effort is spent tracking misplaced documents and placing blame.

D. COMPARISON OF FINDINGS AND METHODS WITH LITERATURE REVIEW

Like the previous study conducted at Ft. Saxon[2], our study encompassed many aspects of the current literature on productivity measurement. The only study found in our literature search that specifically echoes our study is the one conducted at Ft. Saxon. Certain portions of a number of other studies in the literature, however, are related and their methods and findings can be compared. We compared our findings at NAS Sloat with those at Ft. Saxon in the next section.

Our study used the industrial engineering definition of productivity as a ratio of output to input. Using this definition, we were able to convert our productivity

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[2] Impact of Office Automation: An Empirical Assessment, by Steven C. Barclift and Desiree D. Linson, December 1988.

measures into measurable, countable units, such as output per worker, to describe what the Purchasing Branch does to achieve its goal. (Christopher, 1986) The inputs were the staff size, grade structure and the amount of overtime used. The outputs were the number of purchase requests processed and the time required to process a requisition (PALT).

Throughout the literature there is skepticism that white-collar productivity can be measured. Cook (1988) sees difficulty in measuring improved customer service and work quality. Using the PALT, which is a measure of the quality of the work performed, we were able to capture improvements in customer service as a result of office automation. Schwartz (1987) believes that with an absence of headcount reduction, there is no easy way to assess white-collar productivity. We had hoped to show a reduction in headcount resulting from the installation of SACONS. However, with the effect of the manning increase mandated by the PMR inspection and the hiring freeze in FY 88, this cost saving was not realized.

Some experts advocate the use of attitude surveys for assessing the benefits of office technology. In an effort to determine the usefulness of attitude surveys, we had hoped to administer the Organizational Universe Survey to the Purchasing Branch staff. However, we eliminated this part of our study at the request of Purchasing Branch supervisors. We also used surrogate indicators of

productivity, such as sick leave, in an effort to determine if job satisfaction is a key indicator of productivity as Carlson (1974) asserts. Unfortunately, because of our small base population we were unable to arrive at any meaningful conclusions about job satisfaction and productivity.

Finally, we hoped to identify the social effects of office automation on the Purchasing Branch staff. Faerstein (1986) uses such terms as "computerphobia" and "techno-stress" to describe the resistance to office automation in the workplace. We used sick leave and group cohesiveness as an indication of the level of stress in the workplace. Although we were unable to identify a reduction in stress as a result of the installation of SACONS, there was no evidence that the level of stress increased with the introduction of office automation. In addition, in interviews with Purchasing Branch supervisors, there was no evidence of any of the fears that Faerstein says may lead to anxiety and create difficulties in an automated office such as: resistance to change, fear of becoming de-skilled, or fear of isolation or alienation from the rest of the office. Overall, we found that office automation was not seen as a technical threat at NAS Sloat.

E. COMPARISON OF FINDINGS AND METHODS WITH FT SAXON STUDY

Although this study followed the framework developed during the Ft. Saxon study there were some significant

differences in the population, environment, methods, and findings that are worth discussing.

First, the population we studied at NAS Sloat was 85.3 percent smaller than that at Ft. Saxon. The base number of people at NAS Sloat (a measure of input) was small enough to prevent us from reaching any significant conclusions about the social effects of office automation. The Ft. Saxon study, however, found that stress in the workplace was significantly reduced as a result of the installation of SACONS.

Secondly, the environment in which we conducted this study was negatively affected by external events. Because of the PMR inspection in the post-SACONS period, procurement authority was suspended and the authorized manning level for the Purchasing Branch was increased. The loss of procurement authority meant a reduction in the volume of requisitions processed, an increase in the work backlog and a resulting increase in overtime at the end of the fiscal year. The additional manning authorized, as a result of the PMR, prevented any possible reduction in headcount as a result of automation. Where the Ft. Saxon study was able to recognize productivity gains as a result of the installation of SACONS, our study was confounded by outside factors.

Thirdly, the Ft. Saxon study included a cost recovery period for the SACONS system. Because of the effect of the external factors on our findings, we were unable to

calculate a cost recovery period for NAS Sloat. However, it is worth noting the total cost of the system:

Hardware:	$49,478.00
Software:	$10,840.00
Training:	$23,950.00
Maintenance:	$ 5,419.00
Total:	$89,687.00

A breakdown of system hardware and its cost is contained in Appendix A.

Finally, there were significant differences in the findings of the Ft. Saxon study and our study at NAS Sloat. The differences in findings with regard to staff size, overtime, sick leave and volume of requisitions can be explained by the adverse effect of the PMR inspection. There is also a large difference in the percent reduction in PALT realized at Ft. Saxon and at NAS Sloat. This difference can be explained in two ways. First, the pre-SACONS PALT of 17.4 days at NAS Sloat was significantly better than the post-SACONS PALT of 20.9 days at Ft. Saxon in absolute terms. Therefore, there was less room for improvement at NAS Sloat. Secondly, the PALT was also negatively affected by the suspension of procurement authority that resulted from the PMR inspection.

A summary of our findings is provided in Appendix G.

F. ACCOMPLISHMENTS OF THE STUDY

We employed a quasi-experimental research design that gathered archival indicators of inputs, outputs, and social effects before and after the automation of office processes in a single organization. This was accomplished using a classical industrial engineering input/output model of productivity. Using the empirical benchmark for office automation productivity developed during the Ft. Saxon study, we were able to evaluate the strength of the system in a different environment and its ability to overcome the effect of external influences on its productivity. Additionally, we looked at organizational behavior issues and discovered that in this case, office automation had a beneficial impact on small group dynamics.

G. SUMMARY OF SACONS BENEFITS

Because of the many external factors affecting the results of our study, we could not identify an increase in productivity as a result of SACONS. There was, however, a significant improvement in the quality of work performed (PALT) and in the quality of the work environment (group cohesiveness and professionalism). These factors were enhanced in a variety of ways:

- The system controls the worker and the work environment. Each purchase request can be easily tracked by the supervisor who can evaluate employee performance and redistribute workloads according to experience and capabilities.

- There is no unnecessary delay in the processing of difficult purchase requests. In the past, a few experienced buyers handled the majority of the difficult requisitions causing an unnecessary backlog, or inexperienced buyers would set them aside until they could give them proper attention. Now with the work being distributed and monitored by team leaders, this is no longer the case.

- SACONS cuts down on lost time spent tracking misplaced purchase requests. As a result, more time is spent on the purchasing function.

- As a result of SACONS, workers are now responsible for processing the purchase requisition from start to finish. Each action is now considered more important and a new pride in craftsmanship has developed. Thus professionalism has increased.

- Conflict between buyers and typists has been eliminated. In addition, SACONS allows the experienced buyers more time to assist the less experienced buyers. This has greatly increased group cohesiveness.

H. DIRECTIONS FOR FURTHER RESEARCH

Because of the many external factors that confounded our findings at NAS Sloat, the following questions still need to be answered for the productivity story to be complete:

- A follow-on study of SACONS productivity at NAS Sloat is needed. Without the external factors that affected our study, does SACONS increase the productivity of the purchasing Branch?

- A comparative study of the productivity of a tight-control SACONS system with the productivity of a loose-control system such as a word processing operation is needed.

- It will be interesting to note any increased application of SACONS in the future and its effects on productivity. Already the Purchasing Branch is looking into installing a modem hook-up so that certain user activities can access the status of their purchase requests.

- A survey supplemental on change in attitudes among workers is needed to bolster archival findings.

Finally, further productivity studies are needed using archival data within the framework of the experimental design developed in the Ft. Saxon study. Without this, the productivity of office automation cannot be established with the rigor of scientific disproof.

APPENDIX A

SACONS HARDWARE REQUIREMENTS

1. One SACONS-FEDERAL Database Server:	$ 5,836 SE
33MH 80386 Everex Microcomputer.	
2MB RAM on 32 bit bus expandable to 16MB.	
64K cache memory.	
160 MB Hard Disk drive with ESDI controller.	
5 1/4 inch 1.2MB Floppy Disk drive.	
Color Graphics Adaptor with Monochrome screen.	
Internal Tape Backup Unit supporting DA600A cartridges.	
2. One Network Server: *	
Banyan Vines CNS 100 and Console.	$10,483 EA
4MB memory.	
170MB and 146 MB Hard Disk drives.	
Internal Tape Drive.	
Vines Options and additional Hard Disk.	$ 8,459 SE
3. 25 Individual Workstations:	
23 Zenith model ZWX024862 desktop microcomputers.	$ 1,628 EA
2 Zenith model ZFX024862 desktop microcomputers.	$ 1,098 EA
1.1 MB RAM.	
20MB Hard Disk drive.	
360K Floppy Disk drive.	
25 Zenith ZCM-1390/ZVM-1380 Color Monitors.	$ 302 EA
4. Two Laserjet Series II Printers.	$ 1,635 EA
2MB memory.	
Two Tax1 Font cartridge.	$ 366 EA
Total cost, excluding the Network Server, OF SACONS hardware:	$49,478.

* SACONS is only a small application in the Network. The Network serves other Departments.

SACONS SOFTWARE REQUIREMENTS

1. SACONS-FEDERAL Version 1.4 $10,840.

2. Banyan Vines Version 3.01(6)

3. Word Processing: WordPerfect 5.0

APPENDIX B

REQUISITION PROCESSING AT NAS SLOAT

A. MANUAL REQUISITION PROCESSING

1. All requests for materiel or services are received at Issue Control and screened to determine if they can be filled using standard stock material or must be purchased on the open market. If the requested materiel is available from standard stock, a separate document is prepared to requisition the materiel from the Integrated Supply System.[1]

2. All requests for non-standard stock or services are passed to the Comptroller. The Comptroller verifies the availability of departmental funding to purchase the requested materiel or service. If the funds are available, the requisition is approved for purchase. Once approved for purchase, the requisition is stamped with the date. This begins the PALT period.

3. These requisitions are reviewed by the Purchasing Supervisor who assigns the requests to a buyer. Requisitions are assigned to each buyer by type of materiel or service requested. Multiple requisitions received from a

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[1]The Integrated Supply System consists of materiel that is managed by the General Services Administration, the Defense Logistics Agency, or the specific military services.

customer may be grouped together and awarded to one vendor if the materiel or services requested are similar.

4. If the buyer is unfamiliar with an item or the dollar value of the buy is greater than $2500.00, the requisition must be submitted for competition. All sole source requisitions must be presented to the sole source board for approval. If the dollar value of the requisition is under $500.00, an attempt is made to purchase the item via the Imprest Fund Cashier. Compliance with Federal Acquisition Regulations is paramount during the purchasing stage.

5. Next, the buyer prepares the order. The typist transfers all pertinent information from the order form to the DD Form 1155.

6. It is then returned to the buyer for review.

7. The requisition is forwarded to the Contracting Officer for approval and signature, and returned to the typist for distribution.

8. The Receipt Control Division monitors the purchase from this point.

B. AUTOMATED REQUISITION PROCESSING

The following are the changes to the requisition process using SACONS.

1. All requests for materiel or services are reviewed by a technical screener before going to Issue Control.

2. Comptroller-approved requisitions are assigned to either of two team leaders by the Purchasing Supervisor. The team leaders assign the requisitions to the buyers based on priority of the requisitions, workload of the buyers, and the buyers' familiarity with the materiel or service requested. The PALT period begins when a requisition is assigned to a buyer and entered into SACONS.

3. Team leaders use SACONS to screen the requisitions for accuracy and compliance. Corrections to the DD Form 1155 can be made to the file using SACONS.

4. The status of the requisition can be monitored throughout the procurement process.

5. The team leader concept combined with the information available via SACONS have increased the supervisors' ability to match workload with requirements, provide requisition status to customers, and quickly identify problem areas.

APPENDIX C

NAS SLOAT ORGANIZATION CHART

Supply Officer (O4)

Control Division Officer (O2)

Control Division Supervisor (GS-11)

BEFORE SACONS	AFTER SACONS
Purchasing Branch	Purchasing Branch
1 GS-9 Supervisor	1 GS-11 Supervisor
1 GS-7 Lead Buyer	2 GS-9 Team Leaders
2 GS-6 Buyers	3 GS-6 Buyers
4 GS-5/6 Buyers	2 GS-5/6 Buyers
1 GS-4 Procurement Clerk	3 GS-4 Procurement Clerk
1 GS-4 Typist	

APPENDIX D

SACONS-FEDERAL DESCRIPTION

The Standard Automated Contracting System for Federal Agencies (SACONS-FEDERAL) was developed by CACI Federal, Inc., Fairfax, Virginia. It is menu-driven, interactive software designed for the many aspects of small purchase ($25,000 and under) in the Federal Government. The three primary functions of the system are requisition entry, procurement processing, and administrative utilities.

The requisition entry process initiates a procurement in SACONS-FEDERAL by transferring information and data elements of a free form requisition. The specific process determines what type of data is required for the particular purchase.

The procurement processing function is further broken into the small purchases and contracting modules. The small purchases module accepts, generates, tracks, assigns and reports data for purchases. The processes include: Purchase Requests, Award, Vendor Management, Receiving, Reporting, Status and Performance, Stock Item Management, and Form Letters. The contracting module extends purchase request processing to include creation of solicitations and contracts for procurements over $25,000. The contracting module is not used at NAS SLOAT.

The administrative utilities support the entry and maintenance of data used by the requisition entry and small purchase processes. These data include accounting data, local clauses, Federal Supply Codes, and acquisition personnel ID codes.

Every individual menu option in SACONS-FEDERAL is password protected. This allows the system administer to assign each user access to only those functions he or she needs. Although SACONS-FEDERAL is not a classified system, it may contain procurement sensitive data. To protect this information from dissemination outside the circle of approved personnel, SACONS-FEDERAL contains the following security and privacy controls:

- Controlled LOGIN and password procedures that limit access.

- A security option that limits access to the inherent functions in SACONS-FEDERAL.

All of these controls and security features are maintained at the local level by the system administrator.

APPENDIX E

SUMMARY OF SOCIAL DATA

BEFORE SACONS

	PAY PERIOD TOTLAS				PAY PERIOD AVERAGE			
DATE	LEAVE ANNUAL	LEAVE SICK	OVER TIME	TOTAL TIME	STAFF SIZE	LEAVE SICK	OVER TIME	GS LEVEL
10-10	36	16	0	640	8.0	1.6	0.0	6.6
10-24	34	44	0	640	8.0	4.5	0.0	6.6
11-7	40	19	0	640	8.0	1.9	0.0	6.6
11-21	32	0	0	676	8.5	0.0	0.0	6.0
12-5	68	42	0	720	9.0	4.3	0.0	6.3
12-19	78	16	0	708	8.9	1.6	0.0	6.2
1-2	160	17	0	712	8.9	1.7	0.0	6.2
1-16	20	29	0	720	9.0	3.0	0.0	6.3
1-30	10	8	0	718	9.0	0.8	0.0	6.3
2-13	53	40	0	706	8.8	4.1	0.0	6.2
2-27	56	36	0	796	10.0	3.7	0.0	6.1
3-12	44	12	0	960	12.0	1.2	0.0	6.1
3-26	32	29	0	880	11.0	3.0	0.0	6.3
4-9	3	35	0	880	11.0	3.6	0.0	6.3
4-23	92	28	0	800	10.0	2.9	0.0	6.5
5-7	43	33	0	800	10.0	3.4	0.0	6.5
5-21	57	33	0	800	10.0	3.4	0.0	6.5
6-4	42	22	0	800	10.0	2.3	0.0	6.5
6-18	1	3	0	800	10.0	0.3	0.0	6,5
7-2	133	16	0	770	9.6	1.6	0.0	6.2
7-16	91	13	0	792	9.9	1.3	0.0	6.4
7-30	77	16	0	800	10.0	1.6	0.0	6.5
8-13	26	18	57	800	10.0	1.8	5.8	6.4
8-27	1	96	114	800	10.0	9.8	19.9	6.4
9-10	0	114	204	880	11.0	11.7	20.9	6.2
9-24	65	47	284	880	11.0	4.8	20.1	6.2
10-8	12	27	24	768	9.6	2.8	2.5	6.4
10-22	51	0	53	720	9.0	0.0	5.4	6.4
TOTAL	1287	749	816	20,326				
AVG	49.5	28.8	31.4	781.8	9.8	2.9	3.2	6.3
STD. DEV	39.0	25.4	73.6	72.5	0.9	2.6	7.5	0.1

AFTER SACONS

	PAY PERIOD TOTLAS				PAY PERIOD AVERAGE			
	LEAVE	LEAVE	OVER	TOTAL	STAFF	LEAVE	OVER	GS
DATE	ANNUAL	SICK	TIME	TIME	SIZE	SICK	TIME	LEVEL
11-5	1	17	0	856	10.7	1.4	0.0	6.3
11-19	11	38	0	880	11.0	3.1	0.0	5.9
12-3	108	50	0	880	11.0	4.1	0.0	6.5
12-17	52	49	0	960	12.0	4.0	0.0	6.3
12-31	205	16	0	1024	12.8	1.3	0.0	6.0
1-14	11	22	0	1040	13.0	1.8	0.0	6.2
1-28	18	30	0	1040	13.0	2.4	0.0	6.2
2-11	44	18	0	1040	13.0	1.5	0.0	6.2
2-25	62	88	0	1040	13.0	7.2	0.0	6.2
3-11	12	2	0	1040	13.0	0.2	0.0	6.2
3-25	80	26	0	1040	13.0	2.1	0.0	6.2
4-8	90	36	0	960	12.0	2.9	0.0	6.3
4-22	133	39	0	1080	13.5	3.2	0.0	6.0
5-6	8	24	0	1064	13.3	2.0	0.0	6.0
5-20	84	16	0	1000	12.5	1.3	0.0	6.0
6-3	121	0	0	1004	12.6	0.0	0.0	6.0
6-17	75	30	0	920	11.5	2.4	0.0	5.9
7-1	46	0	0	880	11.0	0.0	0.0	6.3
7-15	149	15	0	924	11.6	1.2	0.0	5.9
7-29	82	57	0	1000	12.5	4.6	0.0	6.0
8-12	4	51	282	1020	12.8	4.1	22.9	6.0
8-26	2	16	0	1000	12.5	1.3	0.0	5.9
9-9	32	3	126	1000	12.5	0.2	10.2	5.9
9-23	22	18	339	1000	12.5	1.5	27.6	6.0
10-7	24	16	152	940	11.8	1.3	12.4	6.0
10-21	64	23	0	940	12.0	1.9	0.0	6.1
TOTAL	1540	700	899	25,592				
AVG	59.2	26.9	34.6	984.3	12.0	2.2	2.8	6.1
STD. DEV	51.3	19.8	88.2	61.8	0.8	1.6	7.2	0.1

APPENDIX F

SUMMARY OF MONTHLY PROCUREMENT ACTIONS

BEFORE SACONS			AFTER SACONS		
DATE	NUMBER OF ACTIONS	DOLLAR VALUE	DATE	NUMBER OF ACTIONS	DOLLAR VALUE
OCT 1987	854	1,197,291	*OCT 1988	34	36,483
NOV 1987	971	900,421	NOV 1988	535	270,674
DEC 1987	1256	1,735,191	DEC 1988	1172	2,174,984
JAN 1988	829	764,428	JAN 1989	993	1,042,152
FEB 1988	1185	617,226	FEB 1989	851	754,917
MAR 1988	1322	681,443	MAR 1989	1033	1,145,322
APR 1988	1206	1,045,396	APR 1989	777	753,501
MAY 1988	1042	748,317	+MAY 1989	472	662,065
JUN 1988	451	510,549	+JUN 1989	614	730,437
JUL 1988	895	817,993	+JUL 1989	459	738,320
AUG 1988	1114	908,051	AUG 1989	723	842,838
SEP 1988	1367	1,989,058	SEP 1989	1003	1,348,968
TOTAL	12,492	$11,915,364	TOTAL	8632	$10,464,178
AVERAGE	1041.0	$992,947	AVERAGE	784.7	$951,289
STD.DEV.	282.2		STD.DEV.	234.8	

* Not included in calculations
\+ Procurement Authority suspended

APPENDIX G

SUMMARY OF SACONS STUDY: NAS SLOAT

Capital cost (Total)		$ 89, 687
Hardware for 25-terminal system		$ 49,478
Software		$ 10,840
Training		$ 23,950
Maintenance contract (annual)		$ 5,419
Input: number of personnel	25.5%	increase
Input: grade structure	3.2%	decrease
Input: overtime worked (total)	10.2%	increase
Input: overtime worked per person	12.5%	decrease
Output: volume of purchases (total)	24.6%	decrease
Output: volume of purchases (partial)	14.9%	decrease
Output: quality of work (PALT-total)	13.2%	decrease
Output: quality of work (PALT-partial)	16.7%	decrease
Output: requisitions over $500 (PALT)	24.9%	decrease
Output: productivity (total) requisitions per manhour	67.1%	decrease
Intangible benefit: morale (sick leave usage)	6.6%	decrease
(sick leave usage per person)	24.1%	decrease

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